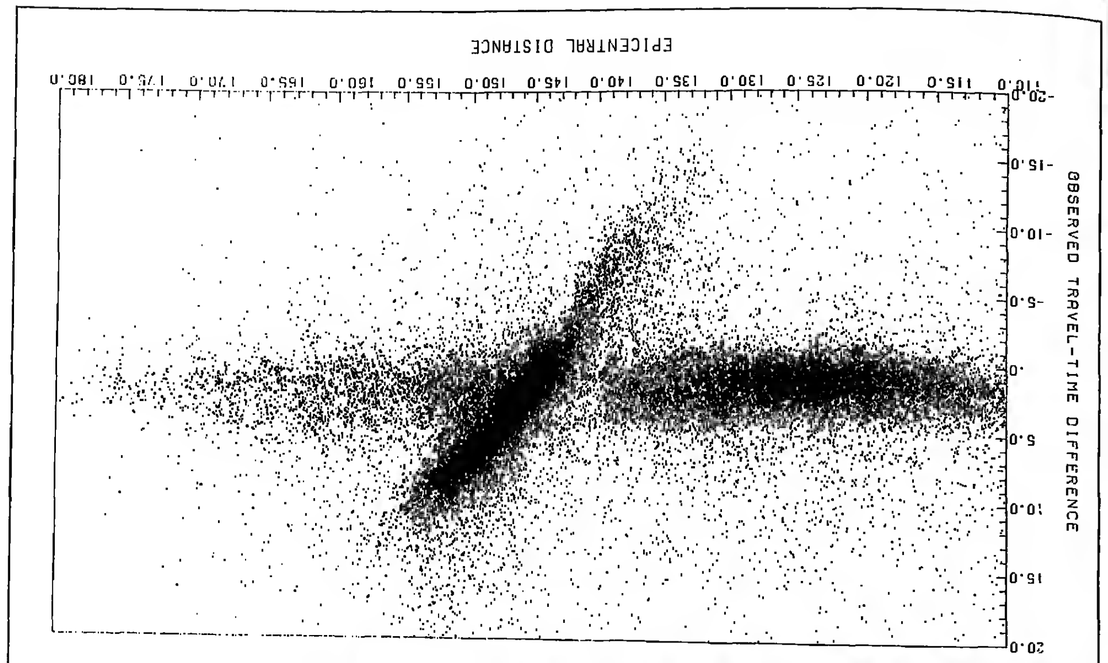


TRANSACTIONS, AMERICAN GEOPHYSICAL UNION
VOLUME 62 NUMBER 23 JUNE 9, 1981

EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION VOL. 62, NO. 23, PAGES 529-536 JUNE 9, 1981

Physical Properties of Rocks

8110 Elasticity, fracture, and flow
THE EFFECT OF SIZE ON MECHANICAL PROPERTIES OF ROCK
M.F. Ashby (Department of Metals & Planetary Science, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139 U.S.A.)
Strengths of certain rock rocks in tension about tenfold as specimen size reduces around 1 meter at still lower sizes, to appear to remain constant. Hard rocks have not been tested over this range of sizes, so their size effect is unknown. Elastic modulus of cemented rocks in soil, are slightly dependent on specimen size up to a meter. However, large fractured samples are 10 to 100 times more compliant than small intact samples. Petrology is also affected, although observations are conflicting.
Graphic, Eng. Lett., Paper 1L0618

8110 Elasticity, fracture and flow
LARGE SCALE LABORATORY TESTING OF NONLINEAR ELASTICITY
Donald C. Palmer (Dept. of Metallurgical and Mineral Engineering, University of Wisconsin, Madison, Wisconsin 53706)
A large scale laboratory testing facility for inelastic fracturing studies is strongly recommended. The study toward the fracturing mechanics with geophysics, the field application of the latter is qualitatively and rapidly growing. The lack of certain practical aspects of the existing theory and theoretical results is lacking, the main reason for the scarcity of experimental work is that until now only small size specimens (linear dimension) have been tested in research facilities. A test not suitable for such studies is nuclear detonation and control. Inasmuch as the behavior of the rock mass, should involve the experimental study, there is missing piece of information of fracture theory.
Graphic, Eng. Lett., Paper 1L0626

8110 Elasticity, fracture, and flow
MICRO-CRACK STUDIES OF BASALTS FROM THE ICELAND RESEARCH DRILLING PROJECT
R. Bonnichsen (Dept. of Geology and Geophysics, Univ. of Wisconsin-Madison, Madison, WI 53706)
S. Sundquist and M.F. Wang
Microcavities in basaltic core from the 1420 borehole in Reydarfjordur, Iceland can be characterized using direct observations with the SEM and inversion of velocity data. In the Iceland basalts, neither method provides an accurate, complete picture of the crack aspect ratio spectrum, but by using both SEM and inversion data a complete spectrum may be obtained. SEM observations provide information on high aspect ratio pores and cracks (a>0.005) that cannot be separated by velocity inversion theory, while velocity inversion theory provides information on low aspect ratio cracks (a<0.005) that are too narrow to be seen with the SEM.
Alteration zone along cracks, blunt ends, and aspect ratios which imply closure pressures greater than the overlying stress all provide evidence that cracks are open in situ. Cracks coincident with grain boundaries are abundant in the basalts (lava and zeugmit an origin early in the rock's history, probably during cooling. Crack healing and alteration are observed to increase with depth, causing a shift in aspect ratio distribution toward higher aspect ratios. (Microcracks, healing, ultrasonic velocity)
J. Geophys. Res., Jnl. Paper 1B0832

8130 Equations of state
ADIABATS (ST/SP)$_S$ AND GRÜNEISEN PARAMETERS OF NaCl up to 30 kbar and 800°C
Reinhard Boehler (University of California, Institute of Geophysics and Planetary Physics, Los Angeles, California 90024)
The adiabatic pressure derivative of temperature (ST/SP)$_S$ of sodium chloride has been measured by adiabatic compression up to 30 kbars and 800°C using an end-loaded piston cylinder apparatus with solid pressure medium. Our measurements at room temperature are in very good agreement with measurements using hydrostatic liquid cells (Boehler et al., 1977). The results can be represented by a power law relationship between (ST/SP)$_S$ and volume of the form $(ST/SP)_S = (ST/SP)_0 (V/V_0)^m$. We estimate $m = 0.1$ and 3.1 at room temperature and 800°C, respectively. The Grüneisen parameter can be calculated from the thermodynamic equation $\gamma = K_S/T \cdot (ST/SP)_S$, where K_S is the adiabatic bulk modulus. γ is found to be independent of temperature within our pressure and temperature range.
J. Geophys. Res., Jnl. Paper 1B0570

6140 Magnetic and electrical properties
FIRST CHEMICAL REMANENT MAGNETIZATION--A NEW DISCOVERY IN EXPLORATION FOR SULFIDE DEPOSITS IN VOLCANIC COVERED AREAS
Lloyd G. Beeso (Consultant, 311 Vivian dr., Hancock, MI 49930) Charles E. Elliot
Redox chemical remanent magnetization (CRM) results from cutback flow associated with a redox potential cell. An active redox cell covered by later volcanics may continue in operation for a period of time, sufficiently long that the current flowing in the overlying volcanics will cause or assist in the crystallization of iron. The crystallization may be either in situ or as an alteration of minerals or by actual migration as a ferrous hydroxide, with flocation at a higher Eh nearer the surface.
Redox CRM will leave a characteristic pattern as a magnetic survey in the rocks. Measurement of the magnetic rock properties and interpretation of resulting patterns can be used to locate the ancient redox cell. Redox cells in nature are usually associated with existing sulfide deposits. Under appropriate conditions, redox CRM can be utilized as an indirect method for sulfide exploration.
Field results for two porphyry sulfide deposits and a massive sulfide deposit under approximately 100 m of post-mineral volcanic cover demonstrate the feasibility of this technique. Field tests in massive sulfide areas indicate that pervasive alteration of

[illegible] redox CRM anomalies do not exist except in the presence of sulfides. Laboratory experiments in the alteration of the redox CRM concept give support to the theory.
Geophysics, Vol. 46, No. 8

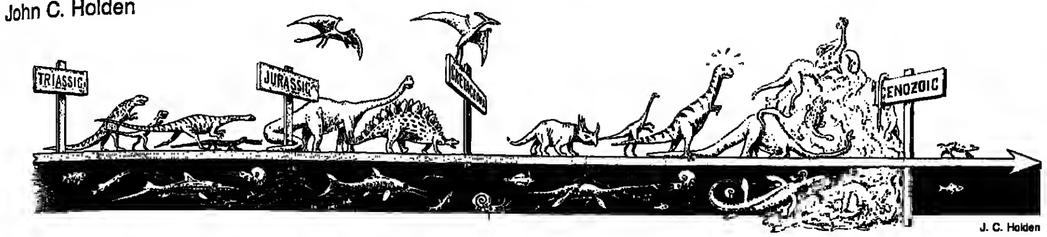
6130 Thermal properties
A REMARK ON THE THEORY OF MEASURING THERMAL DIFFUSIVITY IN THE MODIFIED ANGSTRÖM'S METHOD
S. Ketei Hasumoto (Hokuriku Geological Observatory at Columbia University, Kanazawa, 921, JAPAN)
The theory of measuring thermal diffusivity by the modified Angström's method is extended to the case in which the sample's radiative heat dissipation occurs from its lateral surface. The formulae for the amplitude decay and phase lag of the temperature wave travelling through the sample are presented for two different sample geometries: one for a flat disk sample for which only the heat dissipation from the sample's end surfaces is important, and the other for a long cylindrical sample for which the heat dissipation from both the lateral surface and the end surfaces must be considered. For the flat disk sample, measurement at a single angular frequency of the temperature wave provides data necessary for the determination of the sample's thermal diffusivity. For the sample of finite diameter and length, however, measurements of temperature wave at two discrete angular frequencies are necessary to obtain a complete solution for the thermal diffusivity and other unknown constants. In both cases, to determine the sample's thermal conductivity and the surface conductance of the sample's end surfaces, the bare capacity per unit volume of the sample must be known. Results of experimental data on two lower samples under atmospheric and vacuum conditions are given that for a rectangular parallelepiped, 1 a 1 a 2 cm cube, the difference values obtained by the new theories are within 8 percent of those derived by the conventional theory for a finite bar. Probably, the effect of the sample's geometry still become more distinctive if the sample are more elongated or flatter. The analysis also shows that more accurate defined data are required as the measurement theory becomes more complicated. (Thermal Diffusivity).
J. Geophys. Res., Jnl. Paper 1B0701

6190 Instruments and techniques
BOREHOLE STUDIES OF ROCK ENGINEERING PROBLEMS IN LARGE SCALE LABORATORY EQUIPMENT
Joel J. K. Daemen (Department of Mining and Geological Engineering, University of Arizona, Tucson, Arizona 85721)
A testing facility which includes provisions for access to a cored borehole in a cylindrical rock sample will provide the necessary means to study a number of engineering geomechanics problems that can be investigated readily with presently available equipment. Examples include the stability of deep boreholes, the sealing performance of well cementing and plugging, the influence of size, shape, stress gradient and energy concentration effects on rock failure about underground openings (simulating deep shafts and tunnels in hard intact rock), influence of discontinuities and reinforcement on opening stability, ground-borehole interaction modeling of tunnel support mechanics. Approximate ranges for desirable loading conditions (axial and lateral rock stress, fluid pressure and flow, temperature, geophysical measurement) are suggested for some of these problems as well as requirements for in-hole instrumentation. A large scale laboratory testing facility will find immediate use for the study of many important rock engineering problems. (Borehole stability; borehole seeling; tunnel failure; rock mechanics).
Geophys. Res. Lett., Paper 1L0635

8190 Instruments and techniques
HIGH TEMPERATURE TRIAXIAL-TORSIONAL TESTING MACHINE FOR GRANITE AND ROCK
Stuart P. Beisel, John D. Hsu and Samuel Reid (Tennessee University, Evanston, Illinois 60201)
The purpose and design of a novel high-temperature triaxial-torsional testing machine are described. Tests can be conducted at temperatures up to 600°, the maximum axial load is 4,500 pounds, confining pressure is 30,000 psi and the maximum torque is 3500 lbf. The rotation is controlled with a stepping motor and is variable from 0.1 to 1000 degrees per minute. The machine is designed for testing rock specimens under conditions of moderate temperature, confining pressure, and torque. Specimens are 1 inch in diameter and 2 inches long. (Triaxial testing; torsional testing; high temperature, rock)
J. Geophys. Res., Jnl. Paper 1L0623

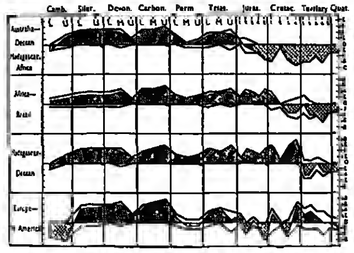
Extinctions: The Democratic Solution

Peter R. Vogt and
John C. Holden



J. C. Holden

The problem of what caused the late Cretaceous extinctions still remains unsolved today (or does it?), after over a hundred years of inquiry supported by an ever increasing supply of theories and data. The classic approach of the multiple working hypotheses method to the problem of wholesale extinctions has apparently not succeeded, at least not until very recently.



An historical example of an 'opinion poll' in earth science: T. Arldt (*Handbook of Paleogeography*, Leipzig, 1917) used the statements or maps of 20 contemporary researchers to compile a table of votes for or against the existence of land bridges in the different geological periods. In Figure 1 of *The Origin of Continents and Oceans* (1966 Dover edition translation of the original 1929 Gebr. Vieweg German edition), Alfred Wegener presented the results of this 'poll' in the graphical form reproduced here. The upper curve shows the number of proponents, the lower curve opponents, and the difference is hatched where 'for' and cross-hatched where 'against.' Wegener argued—and most everyone agrees today—that the times of transition from 'for' to 'against' represent the times of continental breakup.

What is the view of today's earth science community? To find out, we are soliciting your opinions in the accompanying poll. Of course the 'democratic solution' sought here cannot be considered the final answer to extinctions. But by taking the pulse of informed opinion, we hope to stimulate interest in the subject (of extinctions and of opinion surveys). The results of the poll will be reported in these pages at a later date. Whatever your specialty, please take a few minutes to fill out the questionnaire. We don't even insist on your being an earth scientist, but do give us your professional specialization.

Clearly, a hypothesis cannot be completely summarized in a short phrase. Treat each hypothesis as an approximation, and give your basic opinion. Please do not embellish the hypotheses with qualifiers, except under 'other suggestions.'

The questionnaires should be sent either to John C. Holden, Box 38, Winthrop, Washington 98862 or to Peter R. Vogt, Port Republic, Maryland 20676.

We feel the tide of scientific opinion should be routinely gauged, particularly at times of rapid change. Tragically, no opinion surveys were conducted during the Plate Tectonic Revolution (1966–1970). However, it is interesting that Alfred Wegener published in his last book a graphic display of a 'poll' he took on the timing of various ocean basin openings. We are, in a sense, taking that page out of his book.

Peter R. Vogt emigrated to the U.S. from Hamburg, Germany, at the age of 8. After receiving a B.S. at Caltech and a Ph.D. at the University of Wisconsin, he went to work as a research geophysicist at the U.S. Naval Oceanographic Office in Washington, D.C. For 5 years he was a member of the GOFAR project, but when the oceanographic office was moved to Mississippi in 1975, Vogt switched to the Acoustics Division, Naval Research Laboratory, where he is presently employed. Professional interests include marine geology, plate tectonics, magnetic anomalies, and hot spots. Mass extinctions have always fascinated him, for the response of the biosphere to environmental changes must be telling us something about the geophysical processes behind those changes. At home in southern Maryland, Vogt is a disciple of Euell Gibbons and enjoys creating with natural materials, e.g. wood carving.

John C. Holden is a consulting geologist and freelance geoartist. He alternately visits the Late Cretaceous, where he studies dinosaur extinctions, and the Futurozoic, where he is writing a monograph on the decline and extinction of *Homo sapiens*. The remaining time finds him directing the activities of the International Stop Continental Drift Society and editing the much dreaded *ISCDS Newsletter*. In the past, Holden has been reported present at various research facilities including the USGS, ESSA, and NOAA, and several universities. His function at these places remains a mystery. He should not be confused with his twin brother (with also the same name) who has published liberally in the plate tectonic and continental drift literature. Holden is best known for supplying the scientific names to animals that do not exist, including the Loch Ness monster (*Plesiophonia hermonicus*), Bigfoot (*Sasquanthropus megapeditatus*) and the Abominable Snowman (*Deinstapelhelmus hominis*). Interested parties may write for a bibliography.

Questionnaire

Please respond to the statements below by giving the number of the one response that best describes your opinion.

1. Could very well be true.
2. Possible but not probable.
3. Extremely unlikely but not impossible.
4. Impossible—violates present data.
5. No opinion—not familiar with hypothesis.

Statements

The end-Cretaceous extinctions occurred because

1. World climate warmed at the end of the Cretaceous.
2. World climate cooled at the end of the Cretaceous.

2*a*. Assuming warming or cooling was responsible, it was caused by

(i) variation in solar activity;
(ii) interstellar/interplanetary gas or dust;
(iii) variation in terrestrial volcanic activity, possibly of short duration;
(iv) nearby supernova;
(v) collision with asteroid; fine debris discharged into upper atmosphere;
(vi) collision with comet;
(vii) variation in plate tectonic activity, e.g., drop in spreading rate, drop in sea level;
(viii) fresh or brackish water from Arctic Basin inundating world ocean.

3. Radiation increased. This was due to
(a) nearby supernova,
(b) solar explosion,
(c) magnetic reversal and temporary destruction of Van Allen Belt.

4. Fine debris injected into atmosphere by asteroid impact blocked sunlight, decreased photosynthesis, and disrupted food chain.

5. of diseases of one type or another.

6. of 'racial senility.'

7. of breakdown of oceanic circulation, resulting in a widespread anoxic event.

8. of widespread depletion of the oceanic plankton over a short time period, leading to collapse of marine trophic structure.

9. of eustatic sea level fall, leading to restriction of shallow-water habitats.

10. of temporary depletion of critical trace elements such as Cu or Co.

11. of temporary toxic overabundances of trace metals.

12. of temporary O_2 deficiency caused by drop in marine phytoplankton.

13. of depletion of nutrients which was caused by low terrestrial relief, low runoff, and reduced land area.

14. of rise in carbonate compensation depth (CCD) to near sea level.

15. of successful competition by mammals (e.g., eating dinosaur eggs); reptiles to terrestrial vertebrates.

16. The marine micro-fauna/flora extinctions occurred at a different time and therefore do not need to be explained by the same mechanism as the terrestrial (dinosaur) extinctions.

17. The end-Cretaceous extinctions differ only in scale (magnitude) from those throughout most of the Cretaceous and Cenozoic.

18. The end-Cretaceous extinctions represent a unique, or at least extremely rare, type of catastrophe.

19. The cause for the extinctions will be identified more or less certainly within the next few years.

20. The debate will continue because of lack of decisive evidence.

21. The iridium/osmium enrichment recently discovered at the K/T boundary is the decisive breakthrough and could do for massive extinctions what magnetic lineations did for plate tectonics.

22. The length of the extinction event was:
(a) 10^8 years or less,
(b) 10^4 years or less,
(c) much less than a 1000 years, perhaps only a few weeks.

23. The triggering event was truly instantaneous (e.g., an asteroid), although the extinctions occurred over a period of years.

24. Noah built more than one ark—the ark carrying the dinosaurs, etc., sank.

25. The end-Cretaceous extinctions were caused by intervention of extraterrestrial intelligence.

26. Other suggestions? Comments?

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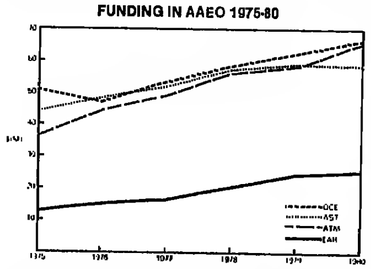
Cover. The Fourth Scientific Assembly of the International Association of Geomagnetism and Aeronomy will be held August 3 to 15, 1981, in Edinburgh, Scotland. For more information, see page 541. (Reprinted with permission from *The Times* of London, pictorial column, December 22, 1953.)

News

NSF Funding Trends in EPS

National Science Foundation trends in funding for research in universities in the Earth and Planetary Sciences (EPS) during the 5-year period 1975–1980 show gradual increases (see figure). The trend for ocean sciences has taken a mostly continuous increase that will continue if the Ocean Margin Drilling Program is supported in fiscal year 1983 as proposed. Support of the program has been in jeopardy in Congress during the past months, but right now the prospects for continued support of the project appear to be favorable.

FUNDING IN AAEO 1975-80



The atmospheric sciences have had increasing stepwise support that could make it the largest program in the EPS portion within a year. The ocean sciences could also take the lead.

Astronomical sciences have what appears to be a leveling off in funding, but at a substantial base. Astronomy will be getting a boost in one sector—space telescope—during the present decade, with NASA funding.

The Earth Sciences Program proper (EAR) is significantly smaller than any of the other programs. Included in EAR are geology, geophysics, and geochemistry. The trend is leveling off; its extension cannot be predicted now. Possibly, it will increase again by fiscal year 1984. [Source: NSF]—*PMB*

Dying Pacific Hot Spot

A team of scientists at the Hawaii Institute of Geophysics report that they have evidence for a new hot spot in the Pacific Ocean. Their discovery was described by Barbara H. Keating at AGU's Spring Meeting in Baltimore late last month. The predicted hot spot, located in the Caroline Islands, halfway between Hawaii and Japan, is the first to show evidence of waning, Keating said.

Hot spots are sources of hot rock that may come from the earth's mantle, explained Keating, assistant professor of marine geology and paleomagnetics at the University of Hawaii. The hot rock melts through oceanic crust and forms a chain of volcanic islands and submarine volcanos. These volcanics show a strict age progression from oldest to youngest.

In the Caroline chain, three major islands—Truk, Ponape, and Kusaie—follow the age progression, Keating's team found. The scientists determined with radiometric dating that Truk is 12 to 14 million years old, Ponape is 8 million years old, and Kusaie is 4 million years old. However, the islands are unusual in that the volume of Truk is twice that of Kusaie. The Hawaiian Emperor Seamount Chain, parallel to the Carolines and also formed by a hot spot, shows the opposite pattern: The youngest islands have greater volumes than the older ones.

Geochemical studies show that the Caroline Islands have the identical source but that the magma that formed the islands changed with time. All of this evidence points to a hot spot that may have been dying during the formation of the Carolines, Keating said. She predicts that the hot spot is located at 4.8°N, 165.7°E.

Corroborative evidence comes from seismic work, local legend, and bathymetric charts, Keating noted. Dan Walker at the University of Hawaii found evidence of seismic activity near Ponape. Also, according to a book published in 1899, Ponape warriors set their sails toward the southeast but hurriedly retreated when they saw fire in the sea. Keating believes that the 'fire' actually was an erupting volcano near the predicted hot spot.

Bathymetric charts show that a seamount, evidence of an old volcano, rises from the bottom of the sea north of the predicted hot spot location. Keating says she hopes to confirm the seamount's presence with ocean bottom seismometers this fall.

When Keating used paleomagnetic data to predict the position of the hot spot, the results varied about 2° from her predictions made on the basis of bathymetric and seismic data.—*BTR*

Shuttle Upper Stage for Galileo

NASA has awarded four letter contracts totaling $7,483,000 for design of a modified Centaur launch vehicle and related components for use as an upper stage with the space shuttle. The modified Centaur will be an adaptation of the vehicle that has flown as an upper stage for both the Atlas and Titan boosters over the past 15 years.

All of the contracts are in support of the Galileo mission to Jupiter scheduled for launch in 1985 and the International Solar Polar Mission in 1986.

Under a $3,412,000 contract with General Dynamics Corp., Convair Division, San Diego, Calif., a modified Centaur vehicle will be designed.

A contract for $1,593,000 was signed with Honeywell, Inc., Avionics Division, St. Petersburg, Fla., for the design and development of the inertial measurement group, a part of the self-contained automatic navigation and guidance system.

A $1,545,000 contract with Teledyne Industries, Inc., Northridge, Calif., was awarded for the onboard computer and remote multiplexer unit. The remote multiplexer units comprise the basic airborne data information system to supply inflight data.

All work under these contracts is scheduled to begin about June 1 and continue through Sept. 30, 1981.

Under a $833,000 contract with United Technologies Corp., Pratt & Whitney Aircraft Group, West Palm Beach, Fla., RL10A-3-3A rocket engines will be built. Primary thrust for the Centaur is provided by two of these engines, which develop 33,000 pounds of total thrust. Work will begin on Aug. 1.

The Centaur program is managed by NASA's Lewis Research Center in Cleveland for the Office of Space Transportation Systems' Upper Stage Division, NASA Headquarters, Washington, D.C. [Source: NASA]—*PMB*

Puzzling Over Saturn's Internal Heat

One of the most interesting things to come out of the Voyager experiments, according to Voyager scientist Andrew Ingersoll of Caltech, is the measurement of Saturn's internal heat. Before the Voyager 1 experiments, Saturn didn't fit with science's view of the solar system, he noted.

'Early ground-based observations and Pioneer spacecraft observations indicated that Saturn had too much internal heat,' said Ingersoll. 'One outrageous possibility is that Saturn is only 2 billion years old and therefore has not lost the expected amount of heat. Such a possibility, if true,' he continued, 'would shatter our understanding of solar system formation.'

Infrared detectors aboard Voyager 1 showed that about one half of the helium is missing from Saturn's atmosphere. 'The missing helium, if it had settled out toward the center of Saturn, could just account for the additional energy now being radiated,' Ingersoll told fellow scientists at AGU's spring meeting. Helium raindrops then would tend to form about halfway down towards the center. The large internal heat previously detected includes that released by the helium rain, Ingersoll concluded.—*BTR*

Saturn's Rings: Debris From Satellites

Saturn's rings may be the remains of at least three satellites smashed by a comet about 4 billion years ago. That's the latest word from the Voyager scientists at AGU's Spring Meeting.

The rings are fragments of preexisting satellites, explained Eugene M. Shoemaker of the U.S. Geological Survey in Flagstaff, Ariz. Breakup of the satellites could have been caused by a comet end by the satellite collisions. Satellite fragments then smeared out to form the complex ring system photographed by Voyager 1 last November, he said.

Shoemaker's theory reverses a previous assertion that the rings are the leftovers of cosmic matter from which the satellites were formed.

Mimas, easily identified by the impact crater covering one-fourth of its diameter, is a still-life of cemetery impacts, Shoemaker said. The impact that caused the crater was just below the threshold of breaking apart the satellite, he said. Mimas remained intact, though, a 4-billion-year-old record.

The two cowrbiting satellites—Saturn's tenth and eleventh—also substantiate the fragmental debris theory. Shoemaker said these irregularly shaped moons were once pieces of a larger satellite. Similarly, the *F* ring is the residue of satellites like moons 10 and 11, he added.—*BTR*

New Center for Air-Sea Studies

Prompted by the increasing recognition of links between the oceans and the atmosphere, the University of Rhode Island recently established a Center for Atmospheric Chemistry Studies. Located within the Graduate School of Oceanography, the center researches air/sea interactions and the sources, transport, and reactions of gases and particles in the atmosphere on local, regional, and global levels. Oceanographer Robert A. Duce directs the center.

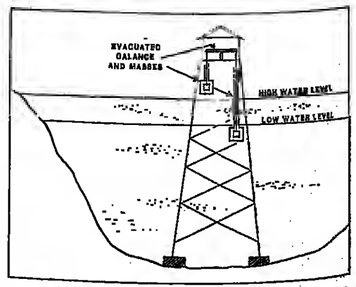
Atmospheric studies underway at the university, including SEAREX (Sea-Air Exchange) and investigations of Arctic air pollution, will continue under the auspices of the center.

The Search for Non-Newtonian *G*

Geophysicist Frank D. Stacey and his colleagues from the University of Queensland, Brisbane, Australia, are attempting to test the laws of gravity. Physics and physical science laboratories have made numerous attempts in recent years to look for deviations in *G*, the gravitational constant, for the purpose of supporting non-Newtonian theories. Physicists would like to include *G*, and gravity fields (and waves), in a unified theory, but the results of the laboratory experiments with mass attraction have been more or less noncommital. Now for the first time in many decades the problem is back in the hands of geophysicists—where it originated.

Frank Stacey, who has been known for his theoretical analysis of the thermal properties of the earth's mantle and core, has been formulating a series of unique experiments that he hopes will provide a good test for the inverse square law. Under development are two separate projects to determine the gravitational attraction of a layer of water: one in the ocean, one in a lake. (Stacey, F. D., Possibility of a geophysical determination of the Newtonian gravitational constant, *Geophys. Res. Lett.*, *5*, 377, 1978; Stacey, F. D., and G. J. Tuck, Non-Newtonian gravity: Geophysical evidence, *Nature*, in press, 1981.)

The ocean measurement will be done jointly with marine geophysicists of Texas A&M. The intention, subject to NSF funding, is to employ the submersible vehicle *Alvin*, and at stationery positions, measure vertical gravity profiles to depths of 3500 km. They plan the first measurements on the Sigsbee Abyssal Plain in the Gulf of Mexico because of its relatively featureless topography. Beneath the 3500-km layer of seawater, *Alvin* will be stabilized, and a stable platform will be used for the grainmeter.



Schematic view of the Splityard Creek gravity experiment. A balance compares the weights of masses suspended in evacuated tubes at different depths in a lake as the lake level is changed. The balance is supported by an observing platform on an electricity pylon that minimizes corrections for the absence of water in the volume occupied by the material of the pylon. [For references cited in text.]

The second experiment will be done in a hydroelectric pumped-storage lake, where the level will change 10 m once or twice a day (see figure). The storage lake is located on Splityard Creek, a minor tributary of the Brisbane River, just upstream from the nearly completed Wivenhoe Dam. A very accurate balance will weigh 10-kg masses that will be suspended in evacuated tubes at different levels of the lake. A capacitance detector will be sensitive enough to measure 1 part in 10^8 of ambient gravity, corresponding to a balance sensitivity of 3 parts in 10^9.

In attempting to find evidence for a non-Newtonian gravitational effect, the two experiments are considered complementary. Both experiments constitute the largest scale system for measurements of this accuracy ever attempted. The masses are large (the layers of water), the systems simple, and the precision is comparable to that of a controlled laboratory experiment. Aside from the search for non-Newtonian effects, the results should provide a new accurate value of *G*.—*PMB*

Forum

Building a Base

AGU has benefited the academic geophysical community since its inception. It has become a major medium of scientific communication through its excellent journals and meetings. It represents us at international meetings and has assisted those who have traveled to such meetings. Also, in these times when academic science, particularly basic science, is under some pressure, AGU can serve an important role in presenting the case for basic research in public forums. For all these reasons AGU deserves the support of the academic community, but why should we contribute to AGU-GIFT? Do we not already pay dues?

AGU GIFT 1980 1985

In my own case, the answer to the questions posed above arises from my own recent experience: 4 years ago I was appointed to a faculty position and began building a research program. In seeking to accomplish this, the desirability of a permanent 'base' of money and resources has become very evident to me. It is extremely difficult, I think, to build and maintain a long-term program of any kind if the only resources available are short-term resources, such as annual dues. Some form of reserve is necessary to handle such matters as coping with unexpected fluctuations in income and meeting special needs. A base of capital equipment, facilities, and space is necessary to ensure the physical continuity of the operation. This is what AGU-GIFT can provide, and I commend it to you as worthy of your support.

Anion M. Dainty
Georgia Institute of Technology

Note from AGU-GIFT Steering Committee: Professor Dainty's check was the first to be received at Headquarters last December.

Equal Opportunities Committee

To encourage women, minorities, and other groups currently underrepresented in science and engineering, the National Science Foundation created, at the request of Congress, the Committee on Equal Opportunities in Science and Technology. Appointments to that committee were recently announced.

Carol Jo Crannell, an astrophysicist at NASA's Goddard Space Flight Center, is one of 16 scientists on the committee. Cora B. Marrett, professor of sociology at the University of Wisconsin, will chair the committee.

Geophysicists

Vinod P. Bhatnagar was recently appointed senior staff physicist in the Department of the Environment of Monitoring Ltd. in Concord, Ontario. Formerly of the University of Western Ontario's physics department, Bhatnagar is also a consultant to the Centre for Research in Experimental Space Science at York University in Downsview, Ontario.

Gordon Eaton will become the dean of geosciences at Texas A&M University on September 1. He succeeds *Earl Cook*, who has held the post for 10 years. Eaton, a former associate chief geologist with the U.S. Geological Survey's geologic division, is known for his research in the volcanic history of Yellowstone National Park and for tectonic studies on the western United States.

The following have been elected Fellows by the American Academy of Arts and Sciences: *Wallace Gary Ernst*, UCLA; *Robert L. Fleischer*, General Electric, Schenectady, N.Y.; *John Imbrie*, Brown University; *Paul Beattie MacCready, Jr.*, Aero Vironment, Inc., Pasadena, Calif.; *Joseph Victor Smith*, University of Chicago; *Hugh P. Taylor, Jr.*, California Institute of Technology; and *M. Gordon Wolman*, Johns Hopkins University.

New Publications

IMS in Antarctica

T. Hirasawa (Ed.), *Mem. Nat. Inst. Polar Res. Spec. Issue 16*, National Institute of Polar Research, Tokyo, v + 144 pp., 1980.

Reviewed by T. J. Rosenberg

The first major symposium on results of the International Magnetosphere Study (IMS) was held at La Trobe University, Bundoora, Victoria, Australia, from November 27 to December 1, 1979. The present volume *IMS in Antarctica* is a collection of 11 of 13 papers on Antarctic research that were presented at this symposium. It is dedicated to Takesi Nagata of the National Institute of Polar Research, Tokyo, for his continuous efforts to develop geophysical research in Antarctica since the IGY.

The post-IMS data analysis phase is still in an early stage. Antarctic research no doubt will be shown to have contributed significantly to realizing many of the objectives of the IMS. But, it seems to me premature to have published a book on this theme now. Nevertheless, the material included is informative and is illustrative of the significant contributions that Antarctic investigations can make in geophysical research. The book serves principally to summarize the Japanese work (8 of 11 papers). Other papers are by Russian (1), New Zealand (1), British (2), and American (1) authors.

Nagata et al., in five papers, summarize auroral-zone measurements from Syowa Station. Information is presented on precipitating electrons, the spectra of VLF and HF plasma waves, and vertical profiles of electron density and DC electric fields. The spatial extent of VLF emissions in magnetic latitude and local time is determined from satellite data received at Syowa. Conjugate relationships for various types of ULF and VLF waves are examined and a classification scheme proposed. A new direction finding technique for auroral hiss emissions is described. Results show that hiss is associated with localized active regions of bright aurora. Kleimenova and Golikov, using simultaneous data from Syowa and Molodezhnaya stations, contrast the spatial extent of continuous and impulsive hiss. Another paper on Syowa observations, by Hirasawa, classifies auroral luminosity pulsations with frequencies of 0.05–40 Hz according to spectral characteristics.

The remaining papers in this volume discuss measurements obtained at subauroral latitudes. Unwin and Cummack discuss the ionospheric signature ('drift spikes') of large poleward-directed electric fields with a VHF doppler auroral radar operated from the south of New Zealand. Lester and Smith present results from Halley Bay of a whistler study of the bulge region of the plasmapause showing the anomalous occurrence of rapid inward (cross-L) drifts of whistler ducts. Matthews and Yearby compare the properties of magnetospheric VLF line radiation observed at Halley Bay with those of power line harmonic radiation as observed at Siple Station. Last, the paper by Bell et al. shows that signals from the Siple Station VLF transmitter, propagating in the nonducted mode, are observed continuously over large regions of the plasmasphere.

In sum, these contributions only touch on the variety and scope of the research activities carried out in Antarctica during the IMS. Much of the material has already been published in journals or is on the verge of publication.

T. J. Rosenberg is with the Institute for Physical Science and Technology, University of Maryland, College Park, Maryland.

Classified

Physical Oceanographer/ Geophysical Fluid Dynamicist

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Professor of Space Physics. The Institute of Geophysics and Planetary Physics of UCLA invites applications for an academic ladder faculty position in the field of space physics. The appointment is expected to be made at the level of professor. Applicants should have well established records in research in the area of fields and particles in space, and will be expected to conduct vigorous research programs in space plasma physics. Responses should include a resume of education, professional experience, and published research. Send replies to L. Knopoff, Associate Director, Institute of Geophysics & Planetary Physics, UCLA, Los Angeles, CA 90024

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Postdoctoral Position in Geochemistry/ Cosmochemistry, University of Arizona. Applications are invited for a postdoctoral research associateship in the Lunar and Planetary Laboratory at the University of Arizona. The associate will collaborate with Dr. William V. Boynton in ongoing investigations of the refractory inclusions in carbonaceous chondrites. The selected applicant will have major responsibilities to conduct mineralogical investigations to supplement existing neutron activation analysis studies. Experience with an electron microprobe is essential, experience with neutron activation is desirable. Facilities include a fully automated SEM/microprobe, numerous gamma ray detectors including a Compton-suppression spectrometer, several computers and a TRIGA reactor.

Applications, accompanied by a resume, statement of research interests, and complete bibliography, should be sent to Dr. William V. Boynton, Lunar and Planetary Laboratory, University of Arizona, Tucson, Arizona 85721. Letters of recommendation, directed as above, should be requested from at least three persons who are well acquainted with the applicant's accomplishments and potential. To receive full consideration, application materials should be received by August 31, 1981.

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Faculty Positions/University of New Orleans. The Physics Department of the University of New Orleans invites applications for tenure track positions available August 1981. Rank and salary are to be commensurate with experience and training. The department has a policy of encouraging research activities in applied areas which are of mutual interest to the faculty and the local technical community. Candidates with background in computational physics, acoustics, and geophysics are especially encouraged to apply. Current research activities within the department include experimental atomic and molecular physics, solid state physics, cryogenic geophysics, hydrodynamics, and computational physics.

Applicants should send a resume to Professor Edward L. Beeson, Physics Department, University of New Orleans, New Orleans, LA 70122.

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Sedimentologist or Sedimentary Petrologist/University of California, Santa Barbara. [Correction] Applications are invited for a tenure track appointment in soft rock geology to be filled in 1981–82. Rank dependent on qualifications and experience but preference will be given to the assistant professor level. Applicant should normally have a Ph.D. and strong field-orientation and quantitative background. The candidate will be expected to develop a strong research program in sedimentation. The candidate will also be expected to teach at both undergraduate and graduate levels and interact with students and faculty of the department, particularly in the general areas of diagenesis, volcanic processes, paleomagnetics, as well as field geology. Additional duties may include teaching physical geology and summer field geology.

Please send resume, other documentation of abilities, and four letters of recommendation by August 31, 1981 to Dr. Arthur G. Sylvester, Chairman, Department of Geological Sciences, University of California, Santa Barbara, CA 93106. Telephone (805) 961-3156.

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Research Coordinator
PHYSICAL OCEANOGRAPHY
Skidaway Institute
Savannah, GA.

Skidaway Institute of Oceanography is seeking person with an oceanographic, meteorological or engineering background to join a research team investigating physical oceanographic processes on the continental shelf. This person must operate and maintain a remote oceanographic data acquisition system and must have experience with digital equipment and the processing of data originating from such equipment. He or she will be responsible for checking and calibrating sensors on a scheduled basis, for data editing and for data analysis.

Applicants should have an M.S. degree in a related field or have the equivalent in training and experience. Knowledge of time series analysis procedures and techniques, computer programming, and technical report writing are necessary skills. Independent research and publication of results will be encouraged.

Starting Salary: $16,600-$20,000 depending upon previous experience and qualifications. Send résumé including three references to: Dr. Jack Stanton, Skidaway Institute of Oceanography, P.O. Box 13687, Savannah, GA 31406. Phone (912) 356-2457/2453.

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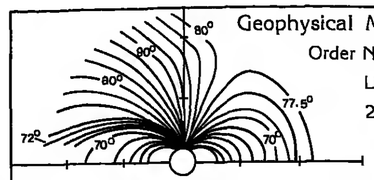

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Quantitative Modeling of Magnetospheric Processes

edited by W.P. Olson
(1979)

Providing an annotated list of quantitative models which serve as a reference on energy particle distribution and magnetic and electric models, this monograph was written in conjunction with the International Magnetospheric Study's activities.

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Physical Oceanographer. Research Assistant Professor. Fixed-term. Ph.D. required in physical sciences and demonstrated ability to conduct independent research in physical oceanography. Will be expected to analyze and model oceanic internal waves and ocean circulation, and will be encouraged to initiate research projects of own choosing. Submit resume and three letters of reference by 1 August 1981 to: G. Ross Heath, Dean, School of Oceanography, Oregon State University, Corvallis, Oregon 97331.

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Faculty Position
OCEANOGRAPHY

Applications are invited for a tenure-earning faculty appointment in physical oceanography; level of appointment and salary commensurate with qualification. Applicant should have a record of scholarly publications demonstrating the ability to interpret oceanographic observations. Duties include teaching graduate level courses in physical oceanography and supervising research of graduate students. Send curriculum vitae, publication list, and names of three references to: Dr. Friedrich Schott, Chairman, Division of Meteorology and Physical Oceanography, Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4800 Rickenbacker Causewey, Miami, Florida 33149.

The University of Miami is an affirmative action equal opportunity employer.

Postdoctoral Research Associate. The Department of Civil Engineering, University of Washington has an immediate opening for a temporary, one-year post doctoral position in water resources and hydrology. Successful applicant will participate in ongoing projects in rainfall-runoff modelling, hydrologic forecasting, and stochastic hydrology. Concurrent independent research on related problems in hydrologic and water resources systems analysis will be encouraged. Please direct transcript, references, and vitae to: Stephen J. Burges or Dennis P. Lettenmaier, Department of Civil Engineering FX-10, University of Washington, Seattle, Washington 98195. (Telephone: 206/543-7135 or 543-2532).

The University of Washington is an affirmative action/equal opportunity employer.

Temporary Staff Positions in Isotope and Trace Element Geochemistry. The research program of the new Geochemistry Division of the Max-Planck-Institute for Chemistry in Mainz is oriented toward the geochemical structure and development of the earth's mantle. Our facilities include a new Varian MAT 261 automated solid source mass spectrometer (in addition to older instruments) for isotopic analysis of Nd, Sr, and Pb.

Available at the institute are also: electron microprobe, ion microprobe, INAA, XRF, spark source MS, and piston-cylinder apparatus. Applications are invited for geochemists with experience in isotope geology and petrologists with experimental experience in trace element partitioning. Appointments are normally made for two years, but a one year extension is possible.

Applications should be sent to A. W. Heimann, Direktor Abteilung Geochemie, Max-Planck-Institute fuer Chemie, Postfach 3060, 6500 Mainz, F.R. Germany.

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Meetings

Delegates to IAGA and IAMAP Assemblies

U.S. scientists planning to attend the Fourth Scientific Assembly of the International Association of Geomagnetism and Aeronomy to be held August 3 to 15, 1981, in Edinburgh, Scotland, and the Third Scientific Assembly of the International Association of Meteorological and Atmospheric Physics to be held August 17 to 22, 1981, in Hamburg, Germany, should notify A. F. Spilhaus, Jr., secretary of the U.S. National Committee of IUGG, at the American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009, so that they can be officially designated as delegates from the United States to those assemblies. ☆

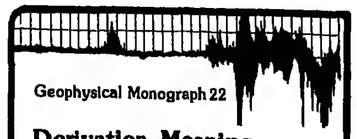
Water and Energy Conference

A two-part conference entitled 'Water and Energy: Technical and Policy Issues' will be held late in the spring of 1982. The Eastern Conference will be held in Pittsburgh, Pa., on May 23–28, 1982; the Western Conference will be in Fort Collins, Colo., on June 27–30, 1982.

Primary objective of the conference is to exchange information and stimulate discussion among technical specialists, public interest groups, and those who have legislative or public policy influence in energy development and associated water resource issues. Among the topics to be included on the agenda are water requirements and availability for energy development; ground and surface water quality; hydrologic impacts; hydropower; end water resource allocations and their legal, economic, end political considerations.

Potential contributors to the Eastern Conference should send abstracts (200 to 400 words) by September 1 to Fritz Kilpatrick, U.S. Geological Survey, National Center, Mail Stop 414, Reston, VA 22092. Abstracts of the same length for the Western conference are also due September 1; send them to Don Matchett, Stone & Webster Engineering Corp., P.O. Box 5406, Denver, CO 80217.

The conference is sponsored by the American Society of Civil Engineers in cooperation with the League of Women Voters and the Council of State Governments; government and technical organizations will also participate. ☆



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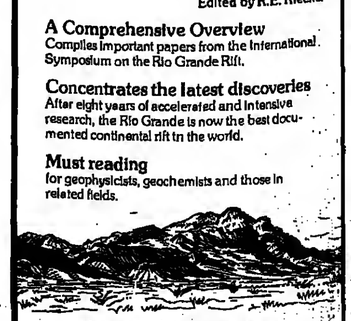

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EPOC '81

The 26th Annual Eastern Pacific Oceanic Conference (EPOC) will be held October 29–31 at the University of Southern California Conference Center at Idlewood, Calif. The program will emphasize progress reports on basic research programs in the region (CODE, Super CODE, VERTEX, OPUS, and CalCOFI, for example); on large applied research programs (such as Bureau of Land Management-sponsored studies along the California coast); and on future cooperative studies (for example, studies of the California undercurrent and the overall California current system).

To facilitate multidisciplinary communication, this meeting will immediately follow the annual CalCOFI meeting.

For additional information, contact R. Michael Laurs, EPOC Secretary, Southwest Fisheries Center, NMFS, La Jolla, CA. Christopher N. K. Mooers is chairman of EPOC.

FIRST ANNOUNCEMENT AND CALL FOR PAPERS

FIRST ANNUAL CONFERENCE ON THE MANAGEMENT, ANALYSIS AND DISPLAY OF GEOSCIENCE DATA

January 27-29, 1982
Colorado School of Mines
Golden, Colorado

Mathematical Geologists of the United States

The conference will provide a forum for geoscientists, mathematicians, statisticians, and computer scientists to discuss progress in theoretical and applied approaches. The program will include invited review papers on the following topics:

- General
- Advances in geostatistics
- Developments in geomathematics
- Computer applications
- Computer graphics
- Database management

Contributed papers are invited on any of these topics. Suggestions or contributions on other, related topics will also be considered by the organizing committee. Those wishing to submit an abstract should send a tentative title of their paper to: Richard B. McCammon, U.S. Geological Survey, National Center 920, Reston, VA 22092. The deadline for receiving this information is **August 16, 1981.**

ASSEMBLY TRAVEL

Third Scientific Assembly, International Association of Meteorology and Atmospheric Physics, August 17–28, 1981,
Hamburg, Germany

Fourth Scientific Assembly, International Association of Geomagnetism and Aeronomy, August 3–15, 1981,
Edinburgh, Scotland

Universal Travel Service, Inc., of Washington, D.C., has been selected as official travel agent for these two assemblies. Contact Anna Monet, Universal Travel Service, Inc., 1825 Connecticut Avenue, N.W., Washington, D.C. 20009 (telephone: 202/687-3202) as soon as possible, indicating your requirements. Every effort will be made to obtain the best schedule and the lowest air fares available, such as super-APEX or group fare.

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Group fare: minimum 40 passengers traveling together, may return individually; tickets issued 21 days in advance. For those attending both assemblies, effort will be made to obtain suitable flights and fares.

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Northwest Airlines has direct service from New York to Glasgow (Prestwick). Pan American has daily service from New York to Hamburg; Northwest, twice weekly.

If possible, the group fare, which is the lowest fare, will be used to have 40 passengers traveling over on the same date.

IAGA/Edinburgh

August 1	JFK/Prestwick	NW #38	depart 7:20 PM	arrive August 2	8:00 AM
August 18	Prestwick/JFK	NW #39	depart 1:10	arrive same day	4:50 PM

Super-APEX: $549.00 Group: $526.00

IAMAP/Hamburg

August 15	JFK/Homburg	PAA #104	depart 9:45 PM	arrive August 16	12:00 noon
August 29	Hamburg/JFK	PAA #101	depart 9:05 AM	arrive same day	12:35 PM
August 14	JFK/Hamburg	NW #30	depart 6:15 PM	arrive August 15	9:30 AM
August 29	Hamburg/JFK	NW #31	depart 12:50 PM	arrive same day	5:25 PM

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Aeronomy

0410 Absorption and scattering of radiation (particles or waves)
OCS PHOTOLYSIS AND ABSORPTION IN THE 200 NM TO 300 NM REGION
R. Neil Rudolph and Edward C. Y. Inn (NASA-Ames Research Center, Moffett Field, CA 94035)
A continuous source with three different interference filters and two different monochromatic sources were used to photolyze OCS in the region from 200 nm to 300 nm. The total quantum yield for the production of CO was measured and the results indicate a primary quantum yield of unity. Absorption cross sections for OCS measured at 0.5 nm intervals are reported as well as the percent change in absorption upon cooling to 195 K. The photochemical implications of absorption are briefly discussed.
J. Geophys. Res., Ocean, Paper 1C0724

0430 Composition (atomic or molecular)
SO2 AND CS2 CROSS SECTION DATA IN THE ULTRAVIOLET REGION
C. Y. Robert Wu (Earth and Space Sciences Institute, University of Southern California, Los Angeles, California 90007) and D. L. Judge
Using synchrotron radiation as a continuous background, the cross sections of SO2 in the 205-326 and 291-340 nm region and of CS2 in the 310-150 nm region have been measured with a bandwidth of 0.05 nm. It has been confirmed that the reported band positions of SO2 in the 180-115 nm region by Watanabe et al. (J. Chem. Phys. 40, 1112, 1964) should all be shifted by ~ 0.3 nm toward shorter wavelengths. An improved application of the vacuum rotation is found for the SO2 and CS2 mixing valence calculations for Venus and Io.
Geophys. Res. Lett., Paper 1L0815

0430 Composition (atomic or molecular)
PRESSURE BROADENING OF CsD BY NITROGEN
N. M. Pickell (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA) D. L. Brinza, and E. A. Cohen
The temperature and pressure dependence of line-width for the J = 1/2 ← 3/2 and J = 15/2 ← 13/2 transitions of CsD have been determined by microwave spectroscopy. The widths for both transitions are found to be the same within experimental error. The width parameter for nitrogen broadening is 3.35 ± 0.17 MHz/torr at 317K and 4.44 ± 0.22 MHz/torr at 218K.
J. Geophys. Res., Ocean, Paper 1C0467

0450 Tides, waves, and winds
HIGH-LEVEL TEMPERATURES AND WINDS OVER TROPICAL INDIA DURING NORTHWARD AND SOUTHWARD MONSOON
G.K.Mukherjee, R.C.Reddy, Gh.V.Ramana Murty, I Indian Institute of Tropical Meteorology, Poona 411005, India)
Study of the rocketsonde temperature and wind data for the tropical stations Thumba (8.5°N, 76.9°E) and Kodaikanal (10.2°N, 77.4°E) suggests a correlation between the occurrence of high-level warmings and westerly shear activity in the Indian region and (ii) a relationship between the stratospheric quasi-biennial oscillation and the monsoon rainfall. In order to test the validity of the above results for other tropical stations and to document the differences in the stratospheric and mesospheric conditions during the years of contrasting monsoon activity, the data for Ascension Island (8.0°S, 14.4°W) and Kwajalein Island (8.7°N, 167.7°E) for two winter seasons (i.e., December to February of 1970-1971, 1971-1972, 1972-1973 and 1975-1976) and for four summer seasons (May to September 1971, 1972, 1978 and 1978) are investigated. During 1972 the year is investigated. During 1972 the monsoon activity was very weak and developing 1978 it was very active.

Variations of 10-20°C within seven days were noticed in the stratosphere/mesosphere region at Ascension Island and Kwajalein during winter and summer seasons. The frequency of occurrence of warmings in both the hemispheres was more during the northern winter than during the summer. The warmings extended to higher levels in the northern hemisphere than those observed in the southern hemisphere. The frequency of occurrence of warmings and thickness of warming layers were less at both the stations in 1972 than in 1979. The zonal wind was strong easterly at the lower stratosphere and weak easterly at the upper stratosphere in 1972. An opposite trend in the zonal wind was noticed during 1978. A quasi-biennial oscillation in the wind in the stratosphere was observed at Ascension Island and Kwajalein which was in agreement with the results obtained from the earlier study for Thumba. Tropical stratosphere, temperatures and winds, (westerly monsoon, quasi-biennial structure),
J. Geophys. Res., Ocean, Paper 1C0824

Electromagnetics

0703 Antennas
PENINSULA IMPEDANCE MEASUREMENTS IN THE MARLBOROUGH SOUNDS, NEW ZEALAND
H. Barr (Geophysical Observatory, PO Box 2111, Christchurch, New Zealand.)
Measurements have been made of the input impedance, at VLF, of a series of transmission lines connected across a peninsula in the Marlborough Sounds, New Zealand. No resonances in the input impedance have been found which cannot be explained in terms of basic earth return transmission line theory, the surrounding sea serving only to provide low impedance line terminations.

In contrast to the assertions of Morgan (1980), the phase velocity of propagation along the earth-return transmission lines has been found to decrease markedly as the cables are lowered to the earth's surface.

It is concluded that the "peninsula" and "island" resonances observed near 10 kHz by Gould (1961) and Morgan (1979) were simply cable resonances, the phase velocity along the cables being here reduced by their proximity to the ground.
(Peninsula, Island, VLF, Antenna)
Rad. Sci., Paper 1R0918

Exploration Geophysics

0930 Magnetic and electrical methods
EXPERIMENTAL USES OF SHORT PULSE RADAR IN COAL SEAMS
F. P. Dono (Geonics, Inc., Mining Research Division, Box 1385, Ponca City, OK 74601) J. C. Fowler, and C. J. Schefero
An unusual borehole series of radar tests conducted to determine the penetration distances and reflection ranges obtainable in coal with currently available short-pulse radar. The various field tests were conducted in 1977 and 1978.
Three different types of test were presented. The first series of tests examined the penetration distances, velocity of propagation, and attenuation versus frequency in a large coal pillar. The velocity of propagation was approximately half that in the air. The tests showed that it was possible to transmit electromagnetic (EM) energy in the range of 20 to 100 MHz through 50 ft of coal. The tests also showed the definite polarization effects that had previously been measured in coal. The second series of tests was designed to show the maximum reflection distances for radar with a center frequency of 100 MHz. Using common-depth-point (CDP) reflection techniques, a twofold CDP line obtained reflections for distances greater than 30 ft. The final series of tests was conducted to locate a six-inch borehole within a coal pillar. The radar system located the hole quickly and easily even though it was 20 ft into the pillar.
The tests have shown that it is possible to use short-pulse radar to probe coal seams before mining.
Geophysics, Vol. 2C, No. 2

0910 Magnetic and electrical methods
THE TELLURIC-MAGNETOTELLURIC METHOD IN TWO- AND THREE-DIMENSIONAL ENVIRONMENTS
John A. Rooh (University of Utah Research Institute, Earth Science Laboratory, 420 Chipeta Way, Suite 120, Salt Lake City, UT 84108) Gerald W. Hohmann and Stan C. Ying
The assumption of spatial uniformity of the horizontal magnetic field, which is an implicit assumption made in straightforward applications of the tellurik-magnetotelluric (T-MT) method, in our always valid near conductivity inhomogeneities. For a two-dimensional (2-D) case, the presence of galvanic scale horizontal magnetic field may very more than a factor of three. The spatial variation of the horizontal magnetic field is not at all over three-dimensional (3-D) inhomogeneities, but it may still constitute significantly to inadequate modeling and phase over shallow inhomogeneities at higher frequencies.

Spatial variation of the horizontal magnetic field can cause T-MT impedance to differ significantly from magnetotelluric (MT) impedance. Consequently, MT modeling of T-MT field data could result in a misleading interpretation of subsurface structure. To avoid erroneous interpretation, numerical modeling programs should calculate actual T-MT data. Resolution of a conductivity structure which produces significant spatial variation of the magnetic field is best with T-MT data than with an equal number of MT data. Several of the largest number of data obtained from a T-MT survey may offset this shortcoming if the data are properly interpreted.
Geophysics, Vol. 46, No. 5

0920 Magnetic and electrical methods
THE INFLUENCES OF CONDUCTIVITY THRUSTS IN THE HOST ROCK ON ELECTROMAGNETIC RESPONSE OF A SPHEROID CURRENTLY BENEATH A LOOP
Alexander Mathieu (Department of Geophysics, Colorado School of Mines, Golden, CO 80401)
A variety of time-domain and frequency-domain electromagnetic (EM) methods has been taken to minerals exploration for detection of conductive ore bodies. Because the responses of these various systems differ markedly from one another, the question arises as to which is the most effective for ore in discovering a buried, conductive ore body. The question can be posed as follows: What type of exploration system provides the best signal-to-noise (S/N) ratio, where signal is defined as the anomalous EM field produced by the conductive target body and noise is defined as EM responses from the surrounding medium? Analytic solution of the problem is tedious and has not yet been reported in the literature. I describe some results for a

special case which reduces the complexity of the problem somewhat. The case treated is that of a conducting spheroid situated directly beneath a source loop. The EM responses caused by currents in the spheroid and in the surrounding medium were computed in both the frequency domain and time domain, using the integral equation approach, supplemented with evaluations of asymptotic expressions for various field components. Results show that the transient method provides the best S/N ratio of the methods considered.
Geophysics, Vol. 46, No. 8

0910 Seismic methods
OBTAINING THREE-DIMENSIONAL VELOCITY INFORMATION DIRECTLY FROM REFLECTION SEISMIC DATA: AN INVERSE SCATTERING FORMALISM
See 0910 Computer applications
Y. S. Weglein (Cities Service Co., Energy Resources Group, P. O. Box 1908, Tulsa, OK 74102) W. E. Boyse and J. E. Anderson
We present a formalism for obtaining the subsurface velocity configuration directly from reflection seismic data. Our approach is to apply the results obtained for inverse problems in quantum scattering theory to the reflection seismic problem. In particular, we extend the results of Moses (1956) for inverse quantum scattering and Razavy (1975) for the one-dimensional (1-D) identification of the acoustic wave equation to the problem of identifying the velocity in the three-dimensional (3-D) acoustic wave equation from boundary value measurements. No a priori knowledge of the subsurface velocity is assumed and all refraction, diffraction, and multiple reflection phenomena are taken into account. In addition, we explain how the idea of migration in processing seismic data is an important part of the proposed 3-D inverse scattering formalism.
Geophysics, Vol. 46, No. 8

0910 Seismic methods
A METHOD FOR CALCULATING SYNTHETIC SEISMOGRAMS WHICH INCLUDE THE EFFECTS OF ABSORPTION AND DISPERSION
See 0910 Computer applications
D. C. Ganley (Formerly Amoco Production Research Center, Tulsa; presently Union Oil Co. of Canada Limited, 335-8th Avenue S.W., P. O. Box 999, Calgary, Alta., Canada T2P 2K6)
A method is outlined for the calculation of synthetic seismograms which include the effects of absorption and dispersion. The absorption model used is the usual model of exponential decay of amplitude with distance given by $A = A_0 e^{-\alpha x}$, where α is a linear function of frequency. This attenuation is accounted for mathematically by allowing the elastic modulus to be a complex velocity and wavenumber, and the reflection and transmission coefficients also become complex functions of frequency. The method is based upon the communication theory approach and is applicable to plane waves in a flat layered model. The source can be placed at an arbitrary depth. The equations are outlined in detail for a particular absorption-dispersion pair taken from Futterman (1962). An example with a surface synthetic seismogram and synthetic traces at several depths is presented.
Geophysics, Vol. 46, No. 8

0910 Seismic methods
MAXIMUM ENTROPY SPECTRAL DECOMPOSITION OF A SEISMOGRAM INTO ITS MINIMUM ENTROPY COMPONENT PLUS NOISE
See 0910 Computer applications
Sven Treitel (Amoco Production Co., P. O. Box 591, Tulsa, OK 74102) Enders A. Robinson
We consider an N-layered elastic medium which is perfectly insulated from its embedding space. Each layer has unit two-way vertical traveltime, and a coincident source-receiver pair is located just below the top interface. If the insulated medium is excited in the remote past, the power spectrum of the resulting impulsive normal-incidence synthetic seismogram is a pure line spectrum, because no random elements exist in the system at the time of measurement. This spectrum is a minimum entropy spectrum. If we add white noise to the seismogram, the power spectrum becomes a maximum entropy spectrum. The maximum entropy spectrum can thus be decomposed into the sum of a minimum entropy spectrum plus white noise; this spectral decomposition is due to Pisarenko (1973). If the insulated medium is excited at time t = 0, the resulting synthetic seismogram differs rather remarkably from the seismogram obtained for excitation in the remote past.
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Geomagnetism and Aeronomy

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1610 Chemistry of the atmosphere
IMPLICATIONS OF NATURAL SOURCES FOR THE LATITUDINAL GRADIENTS OF NO_y IN THE UNPOLLUTED TROPOSPHERE
Sultan Hameed (Laboratory for Planetary Atmospheres Research, State University of New York, Stony Brook, New York 11794) Olga C. Paidoussis and Richard W. Stewart
We investigate the latitudinal variations of the sources of tropospheric odd nitrogen (NO_y) due to lightning discharges and stratosphere-troposphere exchange. By also considering the latitudinal variation of the removal rate in rainout we calculate the NO_y distributions in the troposphere using a one-dimensional model. We then discuss the implications of the characteristic latitudinal gradients of NO_y due to these two sources in view of the GAMETAG measurements in the free troposphere.
Geophys. Res. Lett., Paper 1L0799

1610 Chemistry of the atmosphere
ATMOSPHERIC METHANE (CH_4): TRENDS AND SEASONAL CYCLES
R. A. Rasmussen (Oregon Graduate Center, 19600 N.W. Walker Rd., Beaverton, OR 97006) & M. A. K. Khalil.
Based on twenty-two months of almost continuous, automated, GC/FID measurements of atmospheric CH_4 at Cape Meares (45°N), we show that the concentration of CH_4 is increasing at about 2% per yr (±0.5% yr^{-1}). The data also revealed stable seasonal cycles with peak concentrations in October and minimum concentrations in July. The magnitude of the seasonal variations during these months is about ±20 ppbv from the average (~±1.2%). If the current trend continues, the increased CH_4 concentration may result in a 0.2°K–0.4°K average increase in earth's surface temperature over the next 40 years or so (based on calculations of Wang et al., 1976). The coupling of CH_4 to tropospheric and stratospheric chemical processes is discussed.
J. Geophys. Res., Green, Paper 1C0854

1640 Geochemistry of the solid earth
HYBRID GRANODIORITES INTRUDING THE ACCRETIONARY PRISM, KODIAK, SHUMAGIN, AND SANAK ISLANDS, SOUTHWEST ALASKA
Malcolm Hill (IR-HO Earth Sciences, Northeastern University, Boston, MA 02115), Julia Morris, and Joseph Whelan
A narrow belt of tonalite-granodiorite-granite plutons and batholiths intruded the accretionary prism in southwestern Alaska about 60 m.y. ago, simultaneously with plutonism over 100 km north along the main arc axis. The presence of metasedimentary enclaves, hyenite, and garnet within the intrusions exposed on the Kodiak, Shumagin, and Sanak islands establishes the presence of a crustal component. $\delta^{18}O$ ranges from +10.9–+11.2‰ are extremely high values which require a crustal origin for much of the oxygen in the intrusions. Open-system alteration has disrupted whole-rock Rb-Sr systematics in some samples. Mineral isochrons using unaltered minerals yield an age of 58.7±1.3 m.y. and $^{87}Sr/^{86}Sr$ = 0.70534 ± 10 for the Shumagin batholith, and an age at 62.7 ±1.2 m.y. and Sr/86Sr 0.70533±14 for the Sanak pluton. Comparison of the isotopic data for the intrusions with those of sedimentary rocks in the Kodiak and Shumagin formations requires that a low-$\delta^{18}O$, low-$^{87}Sr/^{86}Sr$ component be present within the intrusions as well. Mixing models combining $^{87}Sr/^{86}Sr$ and Sr contents of various kinds of mafic magmas with partial melts of metasedimentary melt rocks suggest that three types of mafic magmas can satisfactorily duplicate the oxygen isotope signature of the intrusions: (1) a MORB-like magma, (2) a magma derived by partial fusion of altered MORB, or (3) an arc basalt. The MORB model predicts abundances of Rb, Sr, Ba, and REE which are similar to those in the intrusions, while the altered MORB model does not. The arc magma model provides a better trace element match than the unaltered MORB model, but is not as successful as the MORB model.
These intrusions were preceded by a pulse of mafic to intermediate volcanism near or within the accretionary prism, recorded in the Paleocene Ghost Rocks Formation. This volcanism is probably the heat and mass source of the mafic component within the intrusions, and may be related to activity of the nearby Kula-Farallon ridge approximately 60 m.y. ago. (geochemistry, granitic rocks, magmatic arc, Alaska)
J. Geophys. Res., Red, Paper 1B0904

Geomagnetism and Paleomagnetism

1530 Interactions between exterior sources and interior properties (magnetotelluric effects)
THE RELATIONSHIP BETWEEN TEMPERATURE DISTRIBUTION AND THE PERTURBATION OF TIME-VARYING ELECTROMAGNETIC FIELDS FOR A TWO-DIMENSIONAL MODEL OF A SUBDUCTING LITHOSPHERIC SLAB
F.W. Jones (Department of Physics and the Institute of Earth and Planetary Physics, University of Alberta, Edmonton, Alberta, Canada T6G 2J1) L.J. Pascoe, V. Ramaswamy and L.J. Sydora
A two-dimensional numerical model is employed to investigate the perturbation of time-varying electromagnetic fields by a subducting lithospheric slab. A simple thermal conduction model, a model with shear strain heating, and a model which takes into account the production and upward movement of partially melted material from the top of the slab are considered for two periods. Also, a continental/oceanic interface is included. The results indicate that the hot material above the slab considerably affects the spatial behaviour of the electromagnetic field components at the surface. The maximum perturbation of the vertical magnetic component occurs over the point where subduction begins in the simple conduction case, but when shear strain heating is present the maximum perturbation in this component occurs on the continental side of subduction. The nature of the vertical magnetic field perturbation changes considerably when rising melt is present. Apparent resistivity profiles across the subduction zone are substantially different for the three models. The calculated apparent resistivity is significantly reduced when partial melt is present. (Temperature, em-induction, subduction, slab).
J. Geophys. Res., Red, Paper 1B0816

Hydrology

3110 Erosion and Sedimentation
COPING WITH INCREASED STREAM EROSION IN URBANIZING AREAS
W. Whipple, Jr. (Division of Water Resources, Dept. of Environmental Protection, Trenton, N. J. 08625) and J. DiLouie
This paper discusses the increasing channel degradation being experienced in many urbanizing area streams. Increased flooding caused by intensive land development is related to stream erosion through bed load transport theory. Analysis of these relationships leads to conclusions as to channel design criteria. Current design criteria for culverts crossing such streams should be modified. (Stream stabilization, culverts, channel erosion, urbanization).
Water Resour. Res., Paper 1W0835

3130 Groundwater
MASS TRANSPORT 3. ROLE OF HYDRAULIC CONDUCTIVITY DATA IN PREDICTION
Leslie Smith (Dept. of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112) Franklin W. Schwartz
Spatial variations in hydraulic conductivity play a critical role in controlling contaminant transport in groundwater flow systems. A stochastic analysis of mass transport is carried out to investigate various relationships between the number of hydraulic conductivity measurements available to characterize that heterogeneity and the resulting uncertainty in transport predictions. Uncertainties arise both from the unknown spatial variation in hydraulic conductivity and in estimating the parameters of the probability distribution for hydraulic conductivity. The simulations are based on limited sampling of hydraulic conductivity values from a series of hypothetical field sites. Results are interpreted in light of the uncertainty in determining seepage velocities within the flow system. The simulations indicate that considerable hydraulic conductivity data may be necessary to obtain a reasonable degree of confidence in predictions of site behavior. For the sample grids considered, the hydraulic conductivity data do not go far towards reducing the uncertainty in the groundwater velocity. The data seem most effective in locally influencing the mean velocity and constraining the variability in the velocity at the measurement points. A complex dependence is observed between the uncertainty in the velocity field and the hydraulic conductivity measurements. Transport predictions are sensitive to the arrangement of the heterogeneities inferred from the data set. Results of this study suggest that given a moderate number of data points, the unknown patterns of spatial variation in hydraulic conductivity are a more important source of uncertainty than errors in estimating the mean and standard deviation of the hydraulic conductivity distribution.
Water Resour. Res., Paper 1W0921

3130 Groundwater
ON IDENTIFICATION AND VALIDATION OF SOME GEOTHERMAL MODELS
L. Ju. Fradkin (Physics and Engineering Laboratory, DSIR, P.B. Lower Hutt, New Zealand) M.L. Sorey and A. McNabb
Various distributed and lumped-parameter models of the Wairakei geothermal reservoir, New Zealand, are discussed within a unifying mathematical framework. The need for proper system identification is emphasized. The best lumped parameter model obtained by system identification techniques is presented and interpreted as a slow-drainage model. Validation of different models is conducted by studying their forecasting powers with identified parameter values and by testing these identified values for compatibility with additional data. (System identification, model validation, geothermal model, two-phase zone).
Water Resour. Res., Paper 1W0404

3130 Groundwater
MASS TRANSPORT IN DUAL-POROSITY MEDIA
Robert Bibby (Atomic Energy Establishment, Winfrith, Dorset, UK)
In dual-porosity media, such as fissured aquifers in which the rock matrix has a high porosity but low permeability, the transport of contaminants is controlled by molecular diffusion between mobile water in the fissures and essentially static water in the matrix. This transport process has been modelled by incorporating an analytical solution for diffusion from a constant concentration boundary into a 2-dimensional mass transport model. The model uses Galerkin's method of weighted residuals and isoparametric finite elements to solve the flow and transport equations. The model has been successfully applied to a large-scale pollution event, using historical data for calibration. In the absence of such data, identification of model parameters, especially dispersivities, is very difficult. This is because the molecular diffusion between mobile and static water can greatly retard the transport of contaminants that field tests at the appropriate scale are essentially pre-empted. (Groundwater, mass transport, numerical model, dual porosity).
Water Resour. Res., Paper 1W0474

3130 Groundwater
SEASONAL REVERSALS OF GROUNDWATER FLOW AROUND LAKES AND THE RELEVANCE TO STAGNATION POINTS AND LAKE BUDGETS
Mary P. Anderson (Dept. of Geology and Geophysics, University of Wisconsin, Madison, WI 53706) and James A. Munter
Several researchers have observed seasonal reversals in the direction of groundwater flow around lakes. If these reversals are prolonged and are accompanied by the formation of a stagnation point, they may have a significant effect on a lake's water and nutrient budgets. The formation of a stagnation point at a flow-through lake (i.e., a lake that receives groundwater through part of the lake basin and recharges the groundwater system over the rest of the lake basin) is accomplished by the formation of a groundwater mound on the downgradient side of the lake. In this paper the seasonal formation of a stagnation point at Sonie Lake, Wisconsin, is investigated with the aid of two-dimensional transient computer models applied to cross section and areally. The analysis demonstrates the potential for the seasonal formation of a stagnation point at a flow-through lake and provides some insight into the transient development of the stagnation point.
Water Resour. Res., Paper 1W0615

3130 Groundwater
CARBON-14 DATING OF GROUNDWATER IN CONFINED AQUIFERS: IMPLICATIONS OF AQUITARD DIFFUSION
E. A. Sudicky and E. O. Frind (Department of Earth Sciences, University of Waterloo, Waterloo, Ontario, N2L 3G1)
The influence of diffusive losses into fine-grained aquitards on the ^{14}C age interpretation of groundwater in long, thin confined aquifers is examined. An analytical model is developed by coupling two one-dimensional steady-state differential equations, one representing advective-dispersive transport in the aquifer and the other representing diffusion into the aquitards.
The results indicate that aquitard diffusion is a mechanism that can cause a significant reduction in ^{14}C concentrations in a confined aquifer. Groundwater velocities derived from ^{14}C measurements that are unadjusted for diffusion would, therefore, be underestimated. The error that ensues is highly sensitive to the aquifer thickness and the magnitude of the diffusion coefficient. In contrast, the steady-state distribution of ^{14}C is shown to be relatively insensitive to the magnitude of the longitudinal dispersivity value of the aquifer. Dispersivities representative of the upper range of values that have been reported in the literature produced a negligible difference in steady-state ^{14}C concentration compared to results obtained using small dispersivities.
An equation is presented which permits the adjustment of ^{14}C data to account for diffusion, providing the aquifer-aquitard system is not stratigraphically complex and heterogeneous. The analysis can be extended to include age dating isotopes that have half-lives different from that of ^{14}C. The results of this study also apply to age dating in fractured porous media.
Water Resour. Res., Paper 1W0548

3130 Groundwater
PRECONSOLIDATION STRESS OF AQUIFER SYSTEMS IN AREAS OF INDUCED LAND SUBSIDENCE
T. L. Holzer (U.S. Geological Survey), 345 Middlefield Road, Menlo Park, California, 94025)
Aquifer systems in the Eloy-Picacho area, Arizona, the Houston-Galveston area, Texas, and the Tulare-Wasco area and Santa Clara Valley, California, appear to have been overconsolidated by an amount that ranged approximately from 1.6 to 6.2 bars (16 to 63 m of water) before man began to withdraw groundwater from them. The relation between land subsidence and water-level decline in these areas consists of two linear segments. In these areas subsidence per unit water-level decline was approximately constant until water levels had declined an amount that ranged from 16 to 63 m. When water levels declined past these values, subsidence per unit water-level decline increased to larger constant values. Although slow drainage from aquitards may have contributed to this response, it is interpreted here to be caused primarily by natural overconsolidation of the compacting part of the aquifer system. The water-level decline at which the ratio of subsidence to unit water-level decline changed indicates approximately the amount by which the preconsolidation stress exceeded the overburden stress on the aquifer system that existed before groundwater withdrawals began. (Subsidence, groundwater, preconsolidation)
Water Resour. Res., Paper 1W0207

3150 Precipitation
THE MATHEMATICAL STRUCTURE OF RAINFALL REPRESENTATIONS. PARTS I, II, AND III
M. Loyaire and Vijay K. Gupta (Dept. of Civil Eng. University of Mississippi, University, MS 38677)
PART I—A REVIEW OF THE STOCHASTIC RAINFALL MODELS
This is the first of a three part series on the mathematical structure of rainfall models. Several important attempts at modeling rainfall are reviewed. Special attention is given to the mathematical structures that arise in the rainfall descriptions. A general overview of the three part series is given as preface to this part.
PART II—A REVIEW OF THE THEORY OF POINT PROCESSES
Part II constitutes the second of three parts devoted to the mathematical structure of rainfall. An expository, yet current, treatment of those features of Point Process theory which are essential to descriptions of the hydrologic process is developed. A general overview of the three-part series is given in Part I.
PART III—SOME APPLICATIONS OF THE POINT PROCESS THEORY TO RAINFALL PROCESSES
Part III constitutes the final part of three parts devoted to the mathematical structure of rainfall. The objective is to illustrate the scope of the tools developed in Part II in the mathematical description of rainfall and rainfall-driven processes. A general overview of the three part series is given in Part I.
Water Resour. Res., Paper 1W0451

3150 Precipitation
DENDROCLIMATIC RECONSTRUCTION OF ANNUAL PRECIPITATION AMOUNTS IN IOWA SINCE 1680
L. R. Duvick and T. J. Blasing (Environmental Sciences Division, Building 1505, Oak Ridge National Laboratory, P. O. Box X, Oak Ridge, TN 37830)
Tree-ring widths from white oak (Quercus alba) in central Iowa were found to be accurate indicators of total precipitation for a period beginning near the end of the prior growing season and extending until the end of the growing season in the year of ring formation. Regression-based estimates of annual (August–July) precipitation for Iowa were obtained for the 300-year period of tree-ring record (1680–1979). The correlation coefficient between actual and estimated precipitation values was +0.74 for the 60-year period of data used to calculate the regression coefficients, and +0.72 for the preceding 46 years of independent data. These results show that tree rings are reliable indicators of wet and dry periods in Iowa, thereby providing a 300-year record of precipitation variations for use by scientists and planners. (Tree-rings, climate, precipitation records, Iowa).
Water Resour. Res., Paper 1W0541

3150 Runoff and Streamflow
KINEMATIC SUBSURFACE STORMFLOW
Keith Beven (Department of Environmental Sciences University of Virginia, Charlottesville, Virginia 22903)
This paper builds on the analysis of Henderson and Wooding (1964) in comparing simplified models of subsurface stormflow for the case of a sloping soil mantle in which the hydraulic conductivity is constant throughout. It is shown that models based on a kinematic wave formulation may be good approximations to those based on the extended Dupuit-Forchheimer assumptions for values of the non-dimensional parameter λ=4(cosθ/(Ksinθ)) less than about 0.15 in terms of predicting both water table profiles and subsurface stormflow hydrographs. The range of values of slope angle and hydraulic conductivity for which the kinematic approximation is valid is compared to data from field experiments where subsurface stormflow has been shown to be an important component of the response to storm rainfall. It is concluded that the kinematic approximation may be useful for cases of practical interest. (Subsurface stormflow, kinematic model, hillslope hydrology).
Water Resour. Res., Paper 1W0788

3180 Water quality
EFFICIENT DESIGN OF REGIONAL WASTEWATER SYSTEMS: GENERATING AND EVALUATING ALTERNATIVE PLANS
E. Sakawara (University of Louisville, Louisville, Kentucky 40208) E. Erill, and J. Liebman
A simplified method is proposed for analyzing multiperiod design of regional wastewater systems and other systems possessing a similar network-flow structure. The primary objective of the method is generation of multiperiod locations and facility expansion timings. The method is based on several simplifying assumptions.
The solution procedure involves a branch-and-bound algorithm specifically developed for identifying a set of solutions obtained using the initial design flow with a set of solutions obtained using the terminal design flow. A method for comparing the generated multiperiod alternatives is also proposed.
The usefulness of the method is demonstrated using as an example a hypothetical regional wastewater system. (Regionalization, optimization, wastewater systems, branch-and-bound)
Water Resour. Res., Paper 1W0698

3180 Water quality
A MULTIOBJECTIVE BRANCH-AND-BOUND METHOD FOR NETWORK-STRUCTURED WATER RESOURCES PLANNING PROBLEMS
E. Sakawara (University of Louisville, Louisville, Kentucky 40208) M. Yilat
A multiobjective branch-and-bound algorithm is proposed for use in analyzing multiobjective fixed-charge network-flow problems which are found commonly in water resources planning situations. Also proposed is a multiobjective improved value analysis which makes use of the branch-and-bound tree structure and allows the comparison of the importance of facilities in the network as represented by individual arcs or sets of arcs. The mathematical formulation and the solution procedure of the method are described, and the potential usefulness of the method is demonstrated using a hypothetical example problem dealing with a regional wastewater treatment and residual management system. (Multiobjective analysis, regionalization, optimization, wastewater systems).
Water Resour. Res., Paper 1W0497

3199 General or miscellaneous
ON THE EXPECTED DIAMETER OF RANDOM CHANNEL NETWORKS
L.V. Moon (Mathematics Department, University of Alberta, Edmonton, Alberta, Canada)
The mainstream length of river networks tends to be proportional to the area of the corresponding drainage basin raised to a power that increases from about 0.6 for small basins to about 0.5 for large basins. Shreve calculated the expected diameter n(0) of random channel networks with n sources for values of n up to 100. On the basis of this numerical data he concluded that it seems likely that the ratio log r(0)/log n approaches ½ as n increases indefinitely. Our object here is to prove that this is indeed the case.
Water Resour. Res., Paper 1W0684

Meteorology

1715 Chemical composition and chemical interactions
A STUDY OF THE EFFECTIVENESS OF THE Cl2 CATALYTIC OZONE LOSS MECHANISM
D. Wuebbles (Lawrence Livermore National Laboratory, Livermore, California) J. Chang
The importance of catalytic mechanisms involving chlorine species for destroying stratospheric ozone is now well recognized. In this study, we determine that there are at least four catalytic cycles of varying importance for analyzing potential odd oxygen destruction from chlorine species in the stratosphere. The relative efficiency of these cycles varies significantly with altitude. Since individual halocarbons release chlorine atoms over a wide range of different altitudes in the stratosphere, its impact on stratospheric ozone must be due to the combined effect of each of these cycles. Indeed, changes in the vertical ozone distribution for various halocarbon perturbations were found to differ significantly due to differences in the altitude range of inorganic chlorine releases and to differences in relative catalytic cycle efficiencies.
J. Geophys. Res., Green, Paper 1C0852

3125 Convection, turbulence, and diffusion
LONG TERM OBSERVATIONS OF THE ARCTIC MESOSPHERE WITH THE MST RADAR AT POKER FLAT, ALASKA
W.L. Ecklund (National Oceanic and Atmos. Admin., Environmental Research Labs, Aeronomy Lab, Boulder, Colorado 80303) B.B. Balsley
In this report we summarize the results of 28 months of observations of Arctic mesosphere echoes with the 50 MHz radar at Poker Flat, Alaska. Operation with a partially complete system began in February 1979 and has continued on a nearly continuous basis to the present time. The altitude range of the mesospheric echoes obtained during this period shows a pronounced seasonal variation. During summer months the mesospheric echoes are relatively continuous in time and extend from about 80 to 100 km with an unexpectedly strong peak in signal-to-noise ratio at about 85 km. In contrast, in non-summer months mesospheric echoes are less intense and occur at lower altitudes in the range from 55 to 85 km. These lower altitude non-summer echoes are observed primarily during daytime hours when energetic auroral particle precipitation (as determined by the Poker Flat 30 MHz riometer) is present.
J. Geophys. Res., Blue, Paper 1A0737

3715 Electrical phenomena
LAYERED LIGHTNING ACTIVITY
R. R. MacGorman, A. A. Few (Dept. of Space Physics and Astronomy, Rice University, Houston, Texas 77001), T. L. Teer
The horizontal extent of lightning channels reconstructed acoustically from several storms is significantly larger than the vertical extent. Furthermore, an examination of all the reconstructed lightning structure in each of three storms, one in Arizona, one in Colorado, and one in Florida, shows that the lightning activity tends to occur in layers 2-3 km thick. In the Arizona and Florida storms, there were two layers of activity. Temperatures at the lower boundary of the layers were near 4°C and -18°C in the Arizona storm and -11°C and -39°C in the Florida storm. In the Colorado storm, there was a single layer having a lower boundary near the 0°C isotherm. Our interpretation is that each of the two layers in the Arizona and Florida storms is associated with a corresponding charged region in the dipole of the thundercloud charge distribution. We suggest that the singly layer in the Colorado storm was a result of the dipolar regions being closer together in altitude. (Lightning, thunderstorm, atmospheric electricity, storms).
J. Geophys. Res., Green, Paper 1C0812

3740 General circulation
STRATOSPHERIC-MESOSPHERIC MIDWINTER DISTURBANCES: A REVIEW OF OBSERVED CHARACTERISTICS
K. Labitzke (Institut für Meteorologie, F.U. Berlin, Federal Republic Germany)
The midwinter temperature changes in the mesosphere and stratosphere are described using conventional and satellite data. It is shown that over the Northern Hemisphere the so-called stratospheric midwinter warmings extend into the upper mesosphere. The differences between both hemispheres are pointed out. The activity of the planetary-scale waves during the last 16 northern winters and the importance of the amplification of height wave 1 before the beginning of a major warming are discussed. It is shown that during the northern winters the structure of the quasi-stationary waves shows an irregular interannual variability which can be connected with the variability of the polar stratospheric temperatures. In contrast, the southern stratospheric winters are rather regular.
J. Geophys. Res., Green, Paper 1C0652

3700 Interaction of atmosphere with electromagnetic waves
ON DETECTING REFLECTIONS IN PRESENCE OF SCATTERING FROM AMPLITUDE STATISTICS WITH APPLICATION TO D-REGION PARTIAL REFLECTIONS
P. K. Rastogi and O. Holt (Auroral Observatory, P.O. Box 953, Tromsø, Norway)
In many radar experiments which use transmission or scattering of radio waves through a random medium, the received signal is modeled as a reflected sine wave of amplitude A in a scattered narrow-band Gaussian random process of variance 2σ². In this model the received signal amplitude has a Rice family of distribution characterized by a parameter a = A/σ. It is shown that amplitude statistics cannot be used to discriminate weak reflections from scattering (a < 0.0). Behaviour of mean, skewness and kurtosis of the normalized signal amplitude is examined for a constant and an intermittent reflected component. It is shown that intermittency has a strong effect on these.
Applications to a D-region partial-reflection experiment at Tromsø are briefly discussed. It is shown that, at least in some simple cases, enhanced reflections arise from the top and bottom parts of turbulent layers.
Rad. Sci., Paper 1S0860

Mineralogy, Petrology, and Crystal Chemistry

4230 Experimental mineralogy and petrology
POTENTIAL FOR GEOCHEMICAL EXPERIMENTS IN LARGE SCALE TESTS (including ranges of stresses, pore fluid pressures and compositions, and temperatures) R. J. Vidale (Los Alamos National Laboratory, Group CNC-7, MS 514, Los Alamos, New Mexico 87545, USA)
Geochemical problems that would benefit from large scale experiments include: 1) the determination of the physical properties of the many common rocks that are chemically homogeneous on the scale of 5-100 cm but not on a scale of 1-5 cm, 2) the study of the influence of rock textures and compositions and of the chemistry of the pore solution on stress corrosion cracking and 3) the study of chemical transport within gradients in temperature, chemical potentials and isotopic stresses. The ultimate goal of a few well-chosen large scale studies should be the development of predictive models.
Geophys. Res. Lett., Paper 1L0732

4260 Paragenesis, petrography, and petrogenesis
PETROLOGY AND GEOCHRONOLOGY OF METAMORPHOSED VOLCANIC ROCKS AND A MIDDLE-CRETACEOUS VOLCANIC NECK IN THE EAST-CENTRAL SIERRA NEVADA, CALIFORNIA
Ronald W. Kistler (U.S. Geological Survey, Menlo Park, CA 94025, U.S.A.) and Samuel E. Swanson
Metamorphosed Mesozoic volcanic rocks from the east-central Sierra Nevada range in composition from basalt to rhyolite and have ages, based on whole-rock Rb-Sr and U-Pb zircon dating, of about 217-224, 185, 161, 134, and 100 m.y. The major plutons of the batholith in this area are of Triassic (215 to 200 m.y.) and Cretaceous (94 to 80 m.y.) ages. Initial $^{87}Sr/^{86}Sr$ values for the metamorphosed volcanic rocks of the area are in the range from 0.7042 to 0.7058 and are generally different from the values for the surrounding batholithic rocks (0.7056–0.7066).
A circular, zoned granitic pluton, with an outcrop area of 2.5 km², similar in appearance to a ring dike complex, was apparently a conduit for some or possibly all of the middle-Cretaceous metamorphosed volcanic rocks exposed about 5 km to the south in the eastern part of the Ritter Range. Samples from the metamorphosed volcanic rocks and the pluton yield a Rb-Sr whole-rock isochron age of 99.9 ± 0.8 m.y. with an initial $^{87}Sr/^{86}Sr$ of 0.7048 ± 0.0001. Major-element variation diagrams of the pluton and volcanic rocks define coincident compositional trends.
The pluton, intruded into Early Jurassic metamorphosed volcanic rocks (Rb-Sr whole-rock isochron age of 185 ± 4 m.y., initial $^{87}Sr/^{86}Sr$ = 0.70414 ± 0.00009), is composed of a central body of granite that is intruded into and almost completely surrounded by a crescent-shaped outer rim of quartz monzodiorite. Contact relations between the granitic rocks, intrusive in some places and completely gradational at other places, indicate that the quartz monzodiorite was not completely crystallized prior to the intrusion of the granite. Modal mineralogy within the pluton is also consistent with this inferred crystallization history. The granitic rock textures are cataclastic, characterized by a groundmass of feldspar and quartz that surrounds larger grains of feldspar, hornblende, and biotite. Widely spaced aplite dikes from the granite intrude the quartz monzodiorite along its contact between the granitic rocks. The aplite dikes and interstitial alkali feldspar associated with myrmekite in the pluton, being undeformed, indicate crystallization of a small amount of silicate liquid after cataclasis. Aplite compositions suggest a minimum crystallization pressure of 0.5 kb (1-2 km); this depth is consistent with crystallization near the base of a large stratovolcano. The pluton is characterized by steep, linear features, defined by mineral clots and inclusions, that probably formed during the upward movement of the nearly crystallized magma in the volcanic conduit.
The ages of volcanic events relative to the ages of the major intrusive epochs, and the major-element and isotopic compositions of the volcanic rocks relative to the major plutons, indicate that the volcanic rocks are not simply or directly related to the major plutons in the Sierra Nevada. (Volcanic rocks, geochronology, petrology)
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4260 Paragenesis, petrography, and petrogenesis
CHEMICAL EVOLUTION OF MAGMAS IN THE PROTEROZOIC TERRANE OF THE ST. FRANCOIS MOUNTAINS, SOUTHEASTERN MISSOURI, USA, PART I: FIELD, PETROGRAPHIC, AND MAJOR ELEMENT DATA
M. E. Bickford (Department of Geology, University of Kansas, Lawrence, Kansas, USA) J. R. Sides and R. L. Cullers
Chemical evolution of plutonic and volcanic rocks in the St. Francois Mountains has been interpreted on the basis of field distribution of rocks, their petrography, and their major and trace element compositions. Low silica plutons are interpreted as ring plutons intruded into a caldera in the western St. Francois Mountains and are believed to represent samples of the parental magma. Least-squares mixing calculations indicate that a major high-silica pluton which occupies the central part of the proposed caldera and a voluminous ash-flow tuff, believed to be the eruptive that formed the caldera, could have formed by fractional crystallization of plagioclase, hornblende, biotite, alkalic feldspar, sphene, and magnetite from the parental magma. The caldera thus formed above a magma chamber that became zoned by fractional crystallization of liquidous phases occurred.
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4260 Paragenesis, petrography and petrogenesis
GEOCHEMISTRY AND PETROLOGY OF MIO-TERTIARY ASH-FLOW TUFFS FROM THE SIERRA EL VIPULIENTO AREA, EASTERN CHIHUAHUA, MEXICO
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The Sierra el Virulento, located in the Mexican Basin and Range province of eastern Chihuahua, is composed of over 100 m of siliceous high-K calc-alkalic ash-flow tuff ranging in age from 33.7 ± 0.3 to 29.5 ± 0.5 m.y. At least 10% of phenocrysts in the tuffs are zoned feldspar crystals that have sanidine cores and anorthoclase rims. Subordinate phenocrysts include clinopyroxene, biotite, ilmenite, magnetite, sanidine, hornblende, quartz, and orthopyroxene. Pyroxenes are Mg-rich and have a restricted range of Mg-Fe ratios. Fe-Ti oxide minerals equilibrated at high temperatures (880-1055°C) and oxygen fugacities (-log fO_2 = 8.3-11.0). The tuffs are strongly enriched in light rare earth elements (LREE) and have moderate negative Eu anomalies. Initial $^{87}Sr/^{86}Sr$ ratios range from 0.7043 to 0.7065 and show a rough correlation with SiO_2, Sr, and Rb/Sr. The Sr-isotopic compositions suggest that the rocks formed from an isotopically heterogeneous source material and were modified by later crustal contamination. Dacite tuffs may have originated by either fractional crystallization of more mafic magma or by partial melting of crustal material. The series dacite to rhyolite seems to have evolved by a combination of low-pressure fractionation in shallow magma chambers and crustal interaction. If variations from dacite to rhyolite are the result of crystal fractionation, the mineralogy and major-element data suggest that anorthoclase was the dominant fractionating phase.
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4260 Petrogenesis of granite magmas
CHEMICAL EVOLUTION OF MAGMAS IN THE PROTEROZOIC TERRANE OF THE ST. FRANCOIS MOUNTAINS, SOUTHEASTERN MISSOURI, U.S.A., PART II: TRACE ELEMENT DATA
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The St. Francois Mountains igneous complex of Proterozoic age consists of hypabyssal, granite plutons intruded into the overlying rhyolites of similar age. Melting and crystallization models of these rocks suggested by the field, petrographic, and major element contents are further refined using Pb, Rb, Sr, REE (rare-earth element), Th, Sc, and Co contents. There are two groups of relatively undifferentiated plutons associated with the Butler Hill caldera and Taum Sauk area that could have formed by partial melting of lower crustal rocks. The plutons associated with the Butler Hill Caldera (Knoblick and Silvermine granites) could have formed by about 10% aggregate melting of a quartz diorite, graywacke, or subgraywacke. The plutons associated with the Taum Sauk area could have formed by about 30% equilibrium melting of a subarkose or arkose.
More silicic rocks of the Butler Hill caldera could have formed by fractional crystallization. The Silvermine Granite is laterally zoned. Crystallization of plagioclase/biotite/hornblende/magnetite/apatite/zircon/sphene in a ratio of 0.70/0.10/0.15/0.03/0.005/0.001/0.007 from the least differentiated portion of the Silvermine Granite could have formed intermediate portions of the Silvermine. Further crystallization of the Silvermine requires more biotite (Ba begins to decrease) and less hornblende, zircon, and sphene (HREE increase) to precipitate and form the most differentiated portions. Also fractional crystallization of undifferentiated Silvermine-type magma could have produced the sequence of Butler Hill-Breadtray-Granitevilie Granites as residual liquids respectively. The early crystallizing mineral assemblage is dominated by plagioclase and biotite while the late crystallizing mineral assemblage is dominated by quartz, K-feldspar, and lesser plagioclase. The Graniteville Granodiorite in the Pean Park area has the mineral assemblage and composition of a cumulate derived from the Silvermine Granite-late differentiation sequence.
The associated volcanic rocks could not have formed from melts of exactly the same composition of any of the associated intrusive rocks. Rather the volcanic rocks formed from melts of slightly different chemistry.
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4290 Mineralogy, Petrology and Crystal Chemistry
THE SEM EXAMINATION OF GEOLOGICAL SAMPLES WITH A SEMICONDUCTOR BACKSCATTERED ELECTRON DETECTOR
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The paper describes the use of the backscattered electron (BSE) mode of scanning electron microscope (SEM) operation for mineralogical and earth sciences applications. Such operation requires an efficient detector system and of the types presently available the one described here (an annular silicon diode) gives comparable if not superior results to the commercially available scintillator-photomultiplier systems. Other BSE detectors constructed from photodiodes are also found to give good results and are inexpensive and simple to manufacture. Several aspects of BSE image quantification are considered. It is shown how atomic number contrast (which arises from the dependence of the BSE coefficients on composition) may be calculated and the BSE coefficients for a wide range of common minerals are presented. Atomic number contrast gives rise to only a small proportion of the total image signal and in order to remove other sources of contrast special attention should be paid to specimen preparation. Carbon coating is found to be the best method of preventing the specimen from charging because unlike other methods (e.g. gold coating, environmental cell) it does not interfere with image detail or X-ray analysis. The paper shows how compositional information and mineral proportions may be obtained from atomic number contrast images using a multi-channel analyser. (BSE, atomic number contrast, mineralogy, petrology).
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